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CONFLICT OF INTEREST STATEMENT

I have no actual or potential conflict of interest
in relation to this presentation. – so blame me

Sport Science 2: What is a Sport Scientist? – Past, Present, Future or So you want to be a Sport Scientist?

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Background

Sport Science

- *Sport*: a physical activity carried out under an agreed set of rules for competition.
- *Coach*: someone whose function/job is to teach people to improve at a sport
- someone whose job is to train and organize a sports team

google.com

In the context of this discussion we are considering sport as a competitive activity with athletes, coaches and sport scientist involved – non-recreational activity – it is not aimed at improving health or simply having fun, the idea is to win the competition and eventually gain an intense sense of accomplishment and satisfaction.

Sport Science

Science: entails knowledge about the universe that is based on information (data) that can be gathered through careful systematic observation and objective experimentation.

Research: entails the use of existing knowledge and the creation of new knowledge sometimes brought about in a novel and creative manner.

This creativity can generate new concepts, processes, methodologies and understandings.

Indeed, research is an exploration for truth and clarity.

And as with sport, eventually gain a profound sense of satisfaction and accomplishment

Sport Science: the integration of sport and science:

The use of “biology” to understand and develop sport performance - it is not exercise science but grew out of it, sport science requires substantial commitment, which often can be daily commitment.

Conceptual Sport Science Continuums



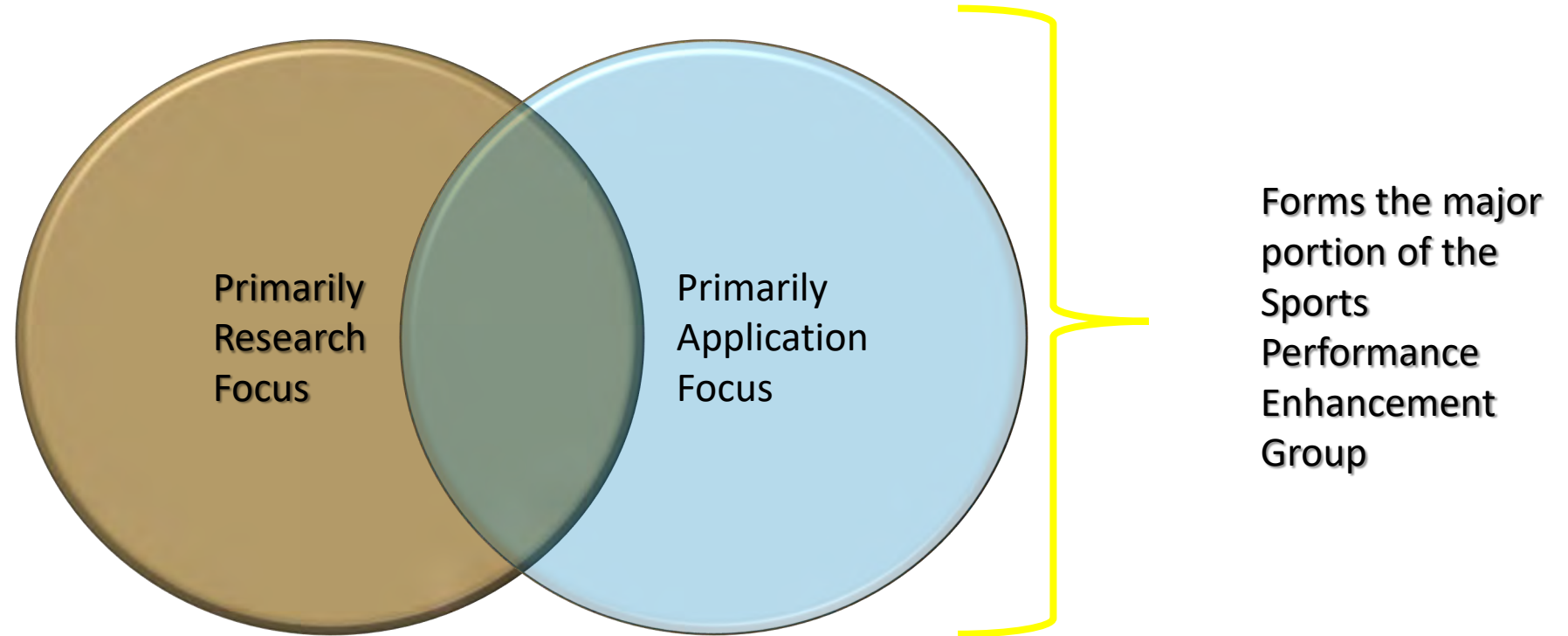
Occasional

Full time



Research Focused

Monitoring/Coaching focused



A sport scientist should have backgrounds in both areas and substantial cooperation between areas should exist

Characteristics of a Sport Scientist

First prerequisite: “drive to know”

In the beginning (almost):

- Eons ago, from an initiation, and likely as a necessity, organisms became more intricate
- Sense organs became more and more complex – the flow of information became more complex
- At some point rudimentary nervous systems reached a degree of complexity that allowed for storage and interpretation of the incoming sensory information
- Finally the reception, storage and interpretation of incoming information overwhelmed the sheer need of necessity

Higher organisms manifested a need to explore and understand their environment
Curiosity – a need to know – is born!

The Human Brain:

- As far as we know (presently) the human brain is the most intricate and complex of any brain on Earth.
- Its capacity to receive, store and interpret information far outstrips simple necessity.
- Indeed, while there can be great rewards; such is the power of curiosity and the “desire to know” that the consequences can sometimes outweigh rewards:

Pandora's box

Eve's serpent and the forbidden fruit.

Twilight Zone (season 3, episode 24)

Hal 9000

However: the “drive to know” has propelled humans into an intellectual world in which we seek to answer major conceptual questions concerning the universe (or at least we should be), including those in sport science.

Indeed science is based on objectivity and the premise that the world is real and can be measured – and thus, a search for truth and clarity

We can still climb mountains and every mountain will teach you something.

It is curiosity that drives the world of science
including (hopefully) sport science.

Second: Knowledge of “Sport Science”

An important aspect of science, that is often overlooked, is its history:

- A historical perspective gives us an understanding of where we have been and where we might go – and a guide for not repeating mistakes.
- It allows us to understand and follow the intellectual evolution of concepts (and details) and learn some things about the development of ideas
- Moreover, a historical knowledge of science (especially your area) provides identity.

Every sport scientist should have good knowledge of
certain *Fundamental Concepts and Ideas*

Mechanistic Cornerstones of Physiology:

- Structure/Function Relationships
- Homeostasis and Regulation
- Compartmentalization
- Biological Energy Transformation
- Communication and Information Flow

The Laws of Thermodynamics: control interactions of everything in the universe - regardless of scale.

Mechanistic cornerstones of Biomechanics (principles of):

- Force (ma)
- Impulse-Momentum Relationship
- Impulse Direction Relationship
- Linked Segments
- The Stretch-Shortening Cycle
- Joint Force Summations
- Continuity of Joint Forces

Mechanistic Underpinnings: a few examples of the scientists answering basic questions relating to sport science (and a lot of other things)

Leucippus (5th century BCE) introduced atomism, the theory that all matter is made of indivisible, imperishable units called atoms. This was greatly expanded on by his pupil Democritus and later Epicurus.

Aryabhata (476–550) an Indian mathematician and astronomer of the classical age of Indian mathematics and Indian astronomy in the Gupta Era Produced works such as the Āryabhaṭīya and the Arya-siddhanta. Determination of square and cube roots, geometrical figures with their properties and mensuration, arithmetic progression problems on the shadow of the gnomon, quadratic equations, linear and indeterminate equations.

Giovanni Alfonso Borelli (1608 - 1679) contributed to the modern principle of scientific investigation by expanding Galileo's practice of testing hypotheses against observation. Related animals (including humans) to machines and used mathematics to confirm his theories. Compared the action of the heart to that of a piston and found that to work properly he derived the idea that the arteries have to be elastic.

Isaac Newton (1642 – 1727) - In the Principia; formulized the laws of motion and universal gravitation

Claude Bernard (1813-1878) - Among many accomplishments, he was one of the first to suggest the use of a blinded experiment to ensure the objectivity of scientific observations. He originated the term *milieu intérieur*, and the associated concept of homeostasis (the latter term being coined by Walter Cannon).

Ramon Cajal (1852 – 1934) - original investigations of the microscopic structure of the brain made him a pioneer of modern neuroscience. Investigated the function of synapses. Developed many of the ideas that became the foundation of the “Neuron Doctrine”.

Walter Cannon (1871 – 1945) - coined the term “fight or flight response”; expanded on Bernard” idea of *milieu intérieur* and developed the concept of homeostasis. Wrote about his Ideas and theories in The Wisdom of the Body (1932).

A.V. Hill (1886 - 1977) one of the founders of the disciplines, “biophysics” and “operations research”; introduced the concepts of maximal oxygen uptake and oxygen debt in 1922. Describe the production of heat and mechanical work in muscles.

Hans Selye (1907 – 1982) - described the physiological stress response to strain (disease – or other “stressors) including physical training. General Adaptation Syndrome (1936)

Albert Szent-Györgyi (1883 – 1986) credited as the first to isolate vitamin C - discovered many of the components and reactions of the citric acid cycle. found that muscles contain actin, which when combined with the protein myosin and the energy source ATP caused muscle fibers to contract.

Arthur Clifton Guyton (1919 – 2003) demonstrated that it was the tissues need for oxygen which was the true regulator of cardiac output. Created the "Guyton Curves" describing the relationship between right atrial pressure and cardiac output form the basis for understanding the physiology of circulation. – Textbook of Medical Physiology

Walter Herzog (1955 -) research focused on the neuro-biomechanics of the musculoskeletal system emphasizing mechanisms of muscle contraction, the role of the structural protein titin, and the biomechanics of joints focusing on mechanisms of onset and progression of osteoarthritis.



A Brief Historical Excursion Through Exercise And Sport Science

Ancient records of wrestling (15, 300 yrs) and physical training (Egypt 4500 yrs ago)

1st Olympics (as far as we know) – 776 BCE

Ancient Greece the use of halteres (lifting stone) dating to as far back as 700 BCE. (early descriptions of weight-training)

Claudius Galenus : Galen (129 CE– c. 216): Described Exercises and training practices of the Gladiators: Divided Exercises into categories: Strong, Rapid, Violent and other

Lucius Flavius): Philostratus (170-247 CE) **Gymnasticus**, contains accounts concerning the Olympic games and athletic contests in general. Described early periodization-Programming” procedures (4 day cycles)

Adreas Vesalius (1514 – 1564): founder of modern human anatomy.

Cristobal Mendez (1500?– 1556 wrote El Libro del Ejercicio Corporal y Sus Provechos (1553).- first book to solely address physical exercise and benefits. described in detail exercises, games, sports and training methods

Leonardo DaVinci (1452-1510):Intensely studied structure and function - how animals and humans move. – Beginnings of biomechanics

Abul-Walid Ibn Rushd, (Averroes), (1126- 1198). Physician, Mathematician Scientist – studied exercise for health and sport Exercises can be intense or mild, fast or slow.. developed early ideas of “speed-strength”.

Giovanni Alfonso Borelli (1608 – 1679): father of Modern biomechanics

1820s-30's PE implemented into school curriculum. German gymnastics was introduced to the USA

1852 First intercollegiate competition was a crew (rowing) race between Harvard and Yale. Intercollegiate athletics would become increasingly popular

Delphine Hanna (1854-1941) became the first woman in US to become a professor of physical education at Oberlin College (1885). Her program evolved into one of the first professional preparation programs for physical education

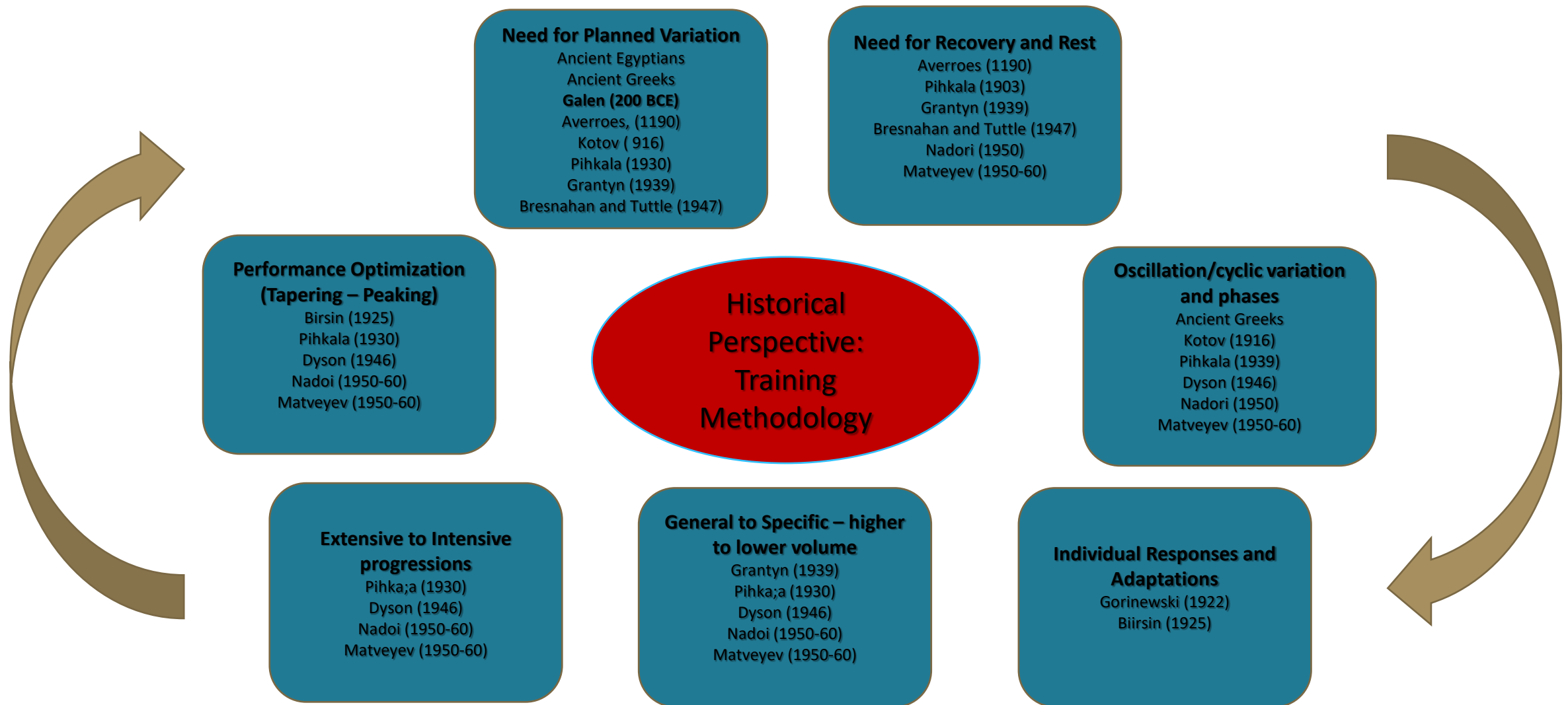
1st Modern Olympics (1896)- Athens: 28 events, and four sports: track and field, gymnastics, target shooting, and fencing.

Formalizing Training Methodology (1900 – Present)

Training for Sport: Coaching - Sport Science and training methodology brief history

See Appendix for more detail

Brief Historical Review: training organization and periodization

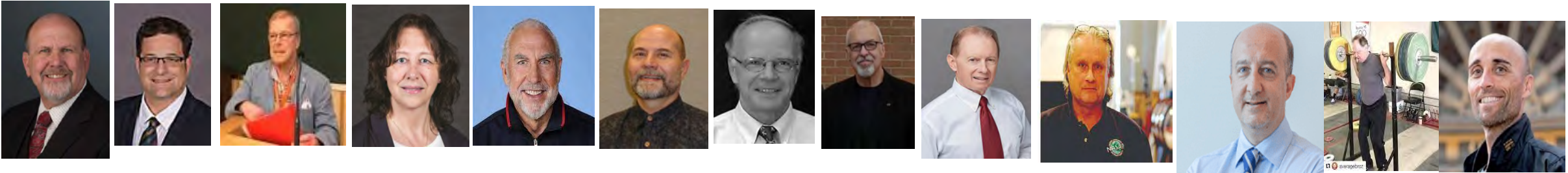


Based on Deweese, et al. 2013 and Stone et al. 2021

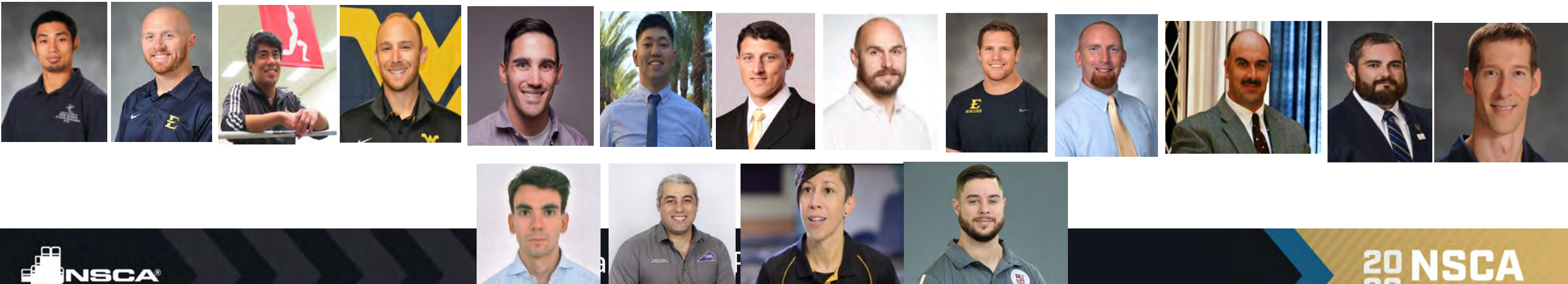
Sport Scientists Currently Making History (or recently have)

The Spectra of Sport Science: (a SMALL SAMPLE: some old, some new –strength-power bias):

Pioneers



Presently



2. A knowledge of sport science continued.

Training:

- Strong foundation in basic sciences (physics, chemistry, biology, physiology, nutrition)
- Strong background in “sports science” (physiology, biomechanics, instrumentation and laboratory techniques, nutrition, etc.).
- The ability to perform critical evaluation and maintain awareness of a rapidly developing body of literature

A drive to answer fundamental/controversial questions such as:

Why is it so important that humans compete and compete physically?

Why is it important to win?

If these first two questions really are important - How should we train to improve performance?



Fundamental

- Exactly how does training strain associate with exercise and training stress?.
- What is the role of Sarcoplasmic versus Myofibrillar hypertrophy?
- How is the nervous system affected by different training schemes?
- To what degree can strength-power training alter bioenergetics and metabolism – effects on work capacity?
- Is equalizing workload really possible (with typical techniques) Is equalizing workload misleading us about training in the real world? –is the equalization really ecologically valid?
- For strength training – does a strength-endurance continuum exist –does its existence depend upon work equalization?
- Is there a method/technique/exercise that will re-stimulate greater gains among well-trained athletes?
- Which one of the myriad of ideas about how to program exercise intensity etc. really work?
- How functional is functional training and what is non-functional training?
- The degree that genetics and epigenetics effects influence adaptation to training?
- Genetic manipulation, AI and AI integration – what does this tell us about our (sport science) future?

Third: be educated beyond sport and science

Third: A sport scientist should be educated beyond sport and science – why?

➤ Adopt an interdisciplinary approach to learning :

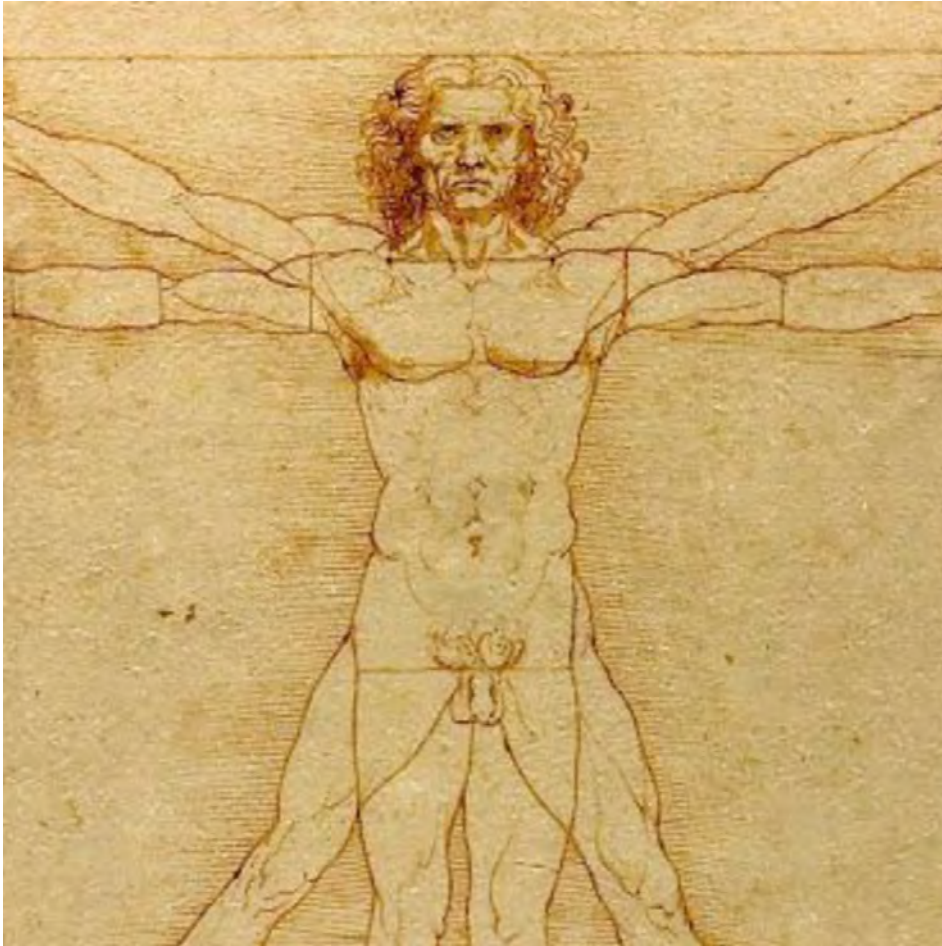
- A broad education intentionally integrating different areas – exposure to a wide range of subjects.
- Sport scientists who can view things from multiple viewpoints often have the tools to attack problems from different perspectives. - Promotes unconventional thinking
- It allows you to become a better citizen – helps in *understanding* other/different viewpoints and aids in *cementing your identity* .
- It allows for important diversions away from the “grind” of the job.
- It helps in recognizing the strength, symmetry and beauty of sport and sport science

Of interest:

- Nobel Prize winners are 15-25 times more likely than the average scientist to engage as an adult in fine arts, crafts, or performing arts.
- Data indicated that the most successful STEM (science, technology, engineering, and mathematics) professionals engage in the arts the most out of all scientists.
- 82% of surveyed scientists and engineers said they would recommend arts and crafts education as a useful or even essential background for a scientific innovator.

<https://www.atc.qld.edu.au/news/the-greatest-scientists-are-artists>

Scientists who were also artists:



Vasari, Giorgio, et al. *Lives of Leonardo Da Vinci*. Getty Publications, 2019.



A man for all seasons:

According to Vasari, Leonardo possessed "great strength and dexterity", being "physically so strong that he could withstand violence and with his right hand he could bend the ring of an iron door knocker or a horseshoe as if they were lead".

Leonardo envisioned science and art as complementary rather than distinct and separate disciplines, and believed that ideas formulated in one domain could—and should—inform the other.

"To develop a complete mind: Study the science of art; Study the art of science. Learn how to see. Realize that everything connects to everything else."

Scientists who were also artists (just a few):

Albrecht Dürer (1471 -1578) Drawing, painting, printing, Mathematician, theorist

Maria Sibylla Merian (1647-1717) Scientific illustrations, drawing, painting naturalist . She was one of the earliest naturalists to observe insects directly.

Isaac Newton (1642 - 1727) drawing, physicist, mathematician - *Principia*

John James Audubon (1785 - 1851) Painting, drawing – biologist/naturalist – described and categorized animals, particularly birds

Alexander Borodin (1883 -1887) Musician, composer, chemist, research concerning organic synthesis, including being among the first chemists to demonstrate nucleophilic substitution, as well as being the co-discoverer of the aldol reaction.

Santiago Ramon Cajal (1852- 1934) Painting, drawing, Neuroscientist – Foundations of the Neuron Doctrine

Albert Einstein (1879 - 1955) Musician (violin)- developed the theory of relativity, made important contributions to the development of the theory of quantum mechanics. Relativity and quantum mechanics are together the two pillars of modern physics. His mass–energy equivalence formula $E = mc^2$, has been described as the "the world's most famous equation"

Heddy Lamar (1914-2000) Actress – along with George Antheil (1900 – 1959) Composer, musician - invented “Spread Spectrum” (frequency hopping) technology that became the forerunner of that used in today's Wi-Fi, Bluetooth and GPS systems

Brian May (1947 -)- Musician, earned a PhD in astrophysics from Imperial College London in 2007 - Chancellor of John Moores University from 2008 to 2013. Science team collaborator with NASA's New Horizons Pluto mission. co-founder of the awareness campaign Asteroid Day

“Scientists’ ability to experience wonder, awe and beauty in their work is associated with higher levels of productivity, job satisfaction and better mental health.”

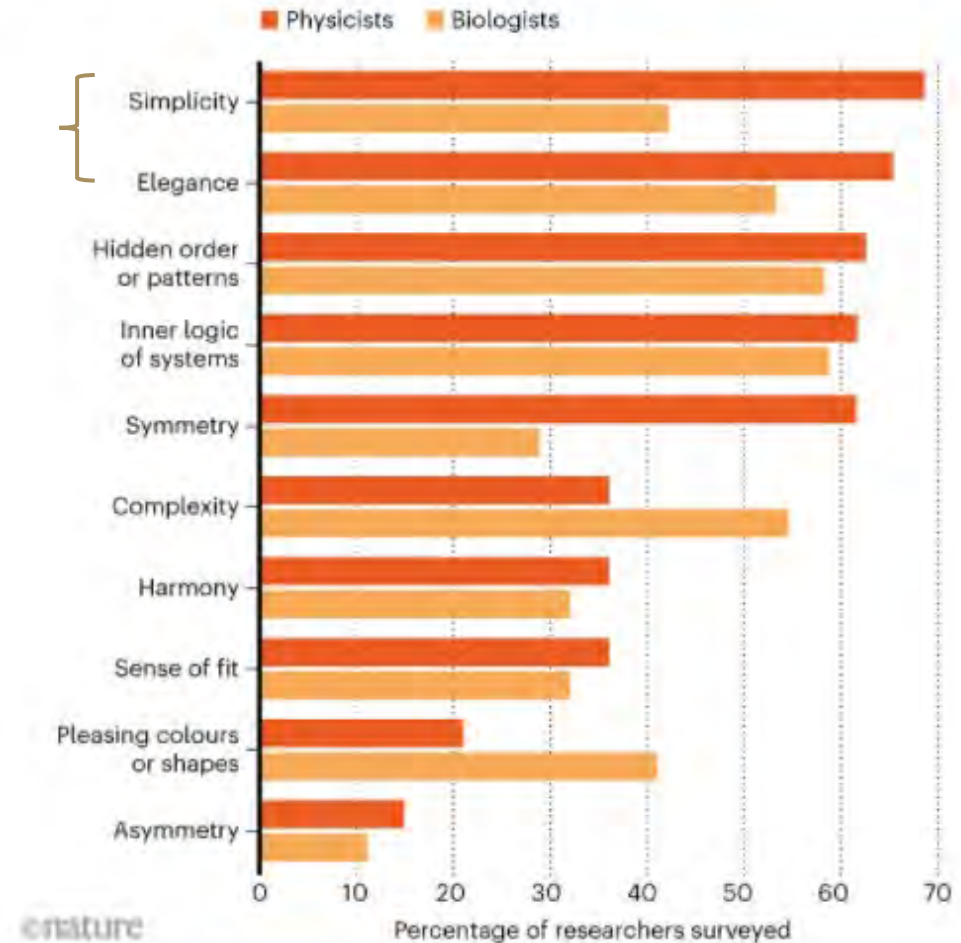
Nature News, 17 March, 2022 –
Vaidyanathan B. Work and Well-being Survey (in Italy, India, UK and USA)

22,840 scientists at 233 universities and
research institutes

Statisticians
please take
note

BEAUTIFUL SCIENCE

Three-quarters of researchers surveyed encounter beauty in the phenomena that they study. Biologists and physicists associate beauty with different aspects of their scientific work.



Source: Work and Well-Being in Science. Source: The Catholic University of America.

Science is an Integration of Logic and Imagination

Fourth: Learn to Think Critically

Fourth: Really Learn to Think Critically

A few things to Consider:

- *sometimes out of the box – sometimes way out
- *learn to observe – did your study results reflect what is actually observed – why and why not?
- *do your results agree with similar studies or with paradigms generally believed – why and why not?
- *check your mental processes – did you really think critically - could it be done differently?
- * Parsimony: the simplest logical explanation is often the best
- *one (or a few) studies do not make reality (statistics are estimators of truth) - statistics do not always provide reality -repeat the basic study more than once
- * all opinions should not be respected (or we would not have reviewers)

Fifth: High Standards